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WO 01/12846 A1

(54) Title: PREPARATION OF METAL OXIDE SUPPORTS LOADED WITH BIOMOLECULES

(57) Abstract: The invention relates to method for the preparation of metal oxide supports loaded with biomolecules, comprising the steps of: (a) activating the surface of the support by means of a silanating agent comprising an amine group; (b) loading the support by attaching biomolecules to the activated surface, characterized in that subsequently the loaded support is treated with an acidic solution, and provided that the method is not used for the preparation of silica wafers which are aminated by silanation using (3-aminoprdeyl)monoethoxydimethylsilane and loaded with oligonucleotides. Similarly, an activated and loaded support may be treated with a basic or neutral solution, provided that the method is not used for derivatization of aluminiumoxide nanoparticles aminated with (3-aminopropyl)triethoxysilane, wherein the basic solution further contains a large excess of N-acetylhomocysteinelactone. This method can for example be used in the preparation of arrays for probe-based assays.

PREPARATION OF METAL OXIDE SUPPORTS LOADED WITH BIOMOLECULES

The invention relates to a method for the preparation of metal oxide supports loaded with biomolecules, to the thus obtained metal oxide supports, to the use of said supports for performing probe-based assays and to a kit of parts comprising said support and a detection means.

The present invention specifically relates to a method for the preparation of metal oxide supports loaded with biomolecules, comprising the steps of: (a) activating the surface of the support by means of an silanating agent comprising an amine group; and (b) loading the support by attaching biomolecules to the activated surface.

Such a method is known, e.g. from WO 99/002266, in which method aluminium oxide membranes are activated using 3-aminopropyl triethoxysilane (APS) after which oligonucleotide probes are covalently coupled to the activated membranes. A similar method is described for aluminiumoxide nanoparticles carrying antigens (Bioconjugate Chem. **1997**, 8, 424-433). Further, for chromatographic purposes, aluminium oxide supports were used for covalent immobilization of concavalin A, after previous activation with APS (Biotechnology and Applied Biochemistry **16**, 221-227 (1992)). Balladur et al., J. of Colloid and Interface Science, 194, 408-418, 1997 describe the adsorption of oligonucleotides on aminopropyl silane-modified silica wafers. These and similarly loaded metal oxide supports are thus useful for instance in probe-based assays, further for carrying biomolecules, e.g. for use as vaccines, and for separating other substances from mixtures by hybridizing, binding or interacting otherwise with those other substances.

A disadvantage of such supports is that a number of amino-groups of the silanating agent comprising an amine group used for the activation of the metal oxide surface, are still present as unloaded amino-groups even after the support has been loaded with the appropriate biomolecule. This may result in unwanted interactions (non-specific or a-specific interactions) of these amino-groups with various substances present in the medium in which the loaded support is used. For example, when used in probe-based assays, such a-specific interactions may generate high background signals disturbing the signals of the analyte, bound to the capture-biomulecules.

It has now been found that when the method of the invention is applied, the non-loaded amino-groups are removed selectively from the surface of the further loaded support without affecting the loaded part of the surface.

The invention thus relates a method for the preparation of metal oxide supports loaded with biomolecules, comprising the steps of: (a) activating the surface of the support by means of a silanating agent comprising an amine group; (b) loading the support by attaching biomolecules to the activated surface, characterized in that subsequently the loaded support is treated with an acidic solution, and provided that the method is not used for the preparation of silica wafers which are aminated by silanation using (3-aminopropyl)monoethoxydimethylsilane, and loaded with oligonucleotides. Such loaded silica wafers have been subject to a study regarding the effect of pH on the maximum adsorbed amount of oligonucleotides onto the aminated silica wafer [Balladur et al., J. of Colloid and Interface Science, 194, 408-418, 1997]. Therefore this invention does not relate to (a method for the preparation of) such silica wafers.

According to another embodiment of the invention the activated and loaded support is subsequently treated with a basic solution (preferably for a prolonged period of time), provided that the method is not used for derivatization of aluminiumoxide nanoparticles aminated with (3-aminopropyl)triethoxysilane, wherein the basic solution further contains a large excess of N-acetylhomocysteinelactone. Such derivatized aluminiumoxide nanoparticles were prepared without the intention to remove aminogroups (Bioconjugate Chem. **1997**, 8, 424-433) and are not an embodiment of the present invention (nor is the method for their preparation).

According to another embodiment of the invention the activated and loaded support is subsequently treated with a neutral solution (preferably for a prolonged period of time).

The usual methods for suppressing a-specific interactions of unloaded amino-groups on different types of supports involve chemical "capping" / "blocking" the unloaded amino-groups or prehybridizing them with DNA (see for example: Science, Vol. 270, **1995**, 467-470; Nucleic Acids Research, Vol. 15 (13) **1987**, 5353--5373; Nucleic Acids Research, Vol. 26 (17) **1998**, 3883-3891, etc.). However, those methods are not very well defined and require more difficult procedures. Furthermore, with those methods the unloaded amino-groups are not actually removed from the surface, which is the case when the method of the present invention is applied.

The method of the invention is well defined and easy to perform and the results, e.g. in terms of signal/background ratio's, are comparable or even better when compared to the usual procedures.

In any situation in which unloaded amino-groups are to be selectively removed from metal oxide supports loaded with biomolecules, the method of the present invention is applicable, provided that a silanating agent comprising an amine group has been used to activate the metal oxide surface.

The pH value of the solution with which the loaded supports may be treated according to the invention, depends substantially on the type of biomolecule attached to the surface and on the way of attaching (loading) the biomolecules to the surface, either covalently or adsorptively.
When the biomolecule is attached to the surface covalently (i.e. they are attached to the amino-groups on the surface via some chemical linkage) and it can withstand both acidic and basic conditions, both acidic and basic solutions may be used for the removal of unloaded amino-groups. If the biomolecule is sensitive to either acidic or basic conditions, respectively a basic or acidic solution must be chosen for the removal of the unloaded amino-groups.
When adsorptively attached (i.e. the biomolecule adheres to the the surface modified with a silanating agent comprising an amine group), also the overall charge of the biomolecule is a relevant parameter. For example, when a negatively charged biomolecule is adsorptively attached to the activated surface of the metal oxide support, it may become detached at a certain pH when the charge of either the biomolecule is reduced by protonation or the charge of the surface is reduced due to deprotonation. For example, an oligonucleotide having a negatively charged backbone will be protonated at very low pH values and it will subsequently be released from the positively charged activated surface of the support. Similarly, the loaded amino-groups are deprotonated at very high pH values (e.g. 11.5) resulting in the release of the negatively charged oligonucleotide.
A person skilled in the art will know how to find the balance between effective removal of the unloaded amino-groups and the intactness of the loaded support. Some preliminary experimentation may be required to find the optimal conditions for the specific circumstances. However, use of an acidic solution is preferred, since the removal of unloaded amino-groups

takes place much more rapidly than in basic conditions. At very low pH values it may even occur almost instantaneously (if the circumstances allow to use such a solution). Preferred are solutions with a pH 2 to 7. For surfaces to which oligonucleotides are attached a solution of pH 4-5 is particularly preferred.

The treatment with a neutral or basic solution is also effective, but requires longer treatment periods. The applicable pH range for a certain situation depends on the reagent used to coat the surface. The pKa of the amine groups influences the charge on the surface and thus the pH at which biomolecules, especially adsorbed biomolecules, stay attached to said surface. Of course the charge distribution on the biomolecules is also important. As explained above, depending on their negative charge, biomolecules may become detached when the pH is very low. The treatment may take several hours up to about a day, depending on the pH value of the solution, the type of metal oxide of the support and the type of reagent used to activate the surface of the support.

The acid- or base-treatment time is not very critical in terms that the performance of the loaded support is not significantly affected after long treatment periods. Also the temperature at which the method may be performed is not very critical. However, temperatures up to 40 °C are preferred. Most preferably the method is applied at room temperature (18 - 24 °C).

Suitable (acidic or basic) solutions for use in the method according to the invention are aqueous buffered solutions adjusted to the desired pH value, for example, but not limited to, for acidic solutions: acetate buffers, phosphate buffers, citric acid buffers, and the like, for basic solutions: disodium hydrogen phosphate or sodium phosphate buffers, sodium tetraborate buffers, tris-buffers, diethanolamine/hydrogen chloride buffers, carbonate buffers, and the like. Appropriate buffers have a concentration of 40 mM, but also other concentrations may very well be applicable.

Metal oxide supports which may be used in the method of the invention are supports of metal oxides of, for example and not limited to, tantalum, titanium and aluminium, silicium as well as alloys of two or more metals and doped metals and alloys. Particularly useful supports are (electrochemically manufactured) porous metal oxide membranes. A preferred metal oxide is aluminium oxide. Preferred porous metal oxide membranes are the membranes mentioned in WO 99/02266.

The surface of the metal oxide support may be activated using different types of silanating agent comprising an amine group. Effective activating reagents are for example 3-aminopropyl triethoxysilane, 4-aminobutyl-dimethyl-methoxysilane, 3-[2-(2-aminoethylamino)ethylamino]-propyltrimethoxysilane, 3-(2-aminoethylamino)propyl-methyldimethyoxysilane, 3-(2-aminoethylamino)propyltrimethyoxysilane, 3-aminopropyl-methyl-diethoxysilane, (3-aminopropyl)-tris[2-(2-methoxyethoxy)ethoxy]silane and 4-aminobutyltriethoxysilane, however also other silanating agents comprising an amine group may be equally suitable. A preferred silanating agent is aminopropyl triethoxysilane (APS) used in an unbuffered aqueous solution. The silanation reaction may be performed in aqueous solution, in organic solution or in the gas phase.

Biomolecules may be attached to the support either covalently or adsorptively. In a preferred embodiment of the invention the biomolecules are adsorptively attached to the activated surface of the support. Preferably, the biomolecules are attached to the surface in spots, thereby forming a (micro)array of spots. A preferred method to spot the surface with biomolecules applies inkjet technology. This technology allows for the accurate deposition of defined volumes of liquid. (See e.g. T.P. Theriault: DNA diagnostic systems based on novel Chem-Jet technologies, IBC Conference on Biochip Array Technologies, Washington DC, May 10, 1995)

In a highly preferred embodiment of the invention an acidic solution of pH 5 is used for the preparation of APS-activated aluminium oxide porous membranes (which are electrochemically manufactured), spotted with arrays of oligonuceotides, which oligonucleotides are adsorptively attached to the activated surface.

Metal oxide supports prepared according to the method of the invention, are very useful for diagnostic purposes, for example in probe-based assays. In particular (micro)arrays, on the surface of which essentially no free amino groups are present that lead to a-specific binding, are very suitable for that purpose. In such arrays, the density of amino groups on the surface area between the spots is significantly lower than the density of amino groups in the spots. Preferably, the arrays comprise different biomolecules in different spots, allowing multi-analyte

detection. An analyte is a substance, usually a biomolecule, in a mixture which may be detected because of its capability to interact specifically with a selected reagens (for example another biomolecule capable of reacting with the analyte) (on a support).

Probe-based assays comprise for example nucleic acid hybridization assays and immunological assays. In such assays, a sample which comprises an analyte is contacted with a loaded support prepared according to the invention. The analyte is subsequently allowed to bind to the biomolecule which is attached to the surface of the support. Detection of binding can be performed by (1) adding a detection means, for example a substance capable of binding to the analyte, which substance is provided with a label, (2) allowing the detection means to bind to the complex of the analyte and the biomolecule, and (3) determining whether the label is present at the position where the biomolecule was attached. Alternatively, the analyte may already have been provided with a label, in which case binding to the biomolecule can be detected directly, without the addition of a detection means.

The present invention therefore also relates to a kit of parts comprising a metal oxide support according to the invention, further comprising a detection means for determining whether binding has occurred between the biomolecules and an analyte. Preferably, such detection means is a substance capable of binding to the analyte and being provided with a label. Such label is in particular useful, if it is capable of inducing a colour reaction and/or capable of bio- or chemo- or photoluminescence.

Biomolecules which may be used in the process of the invention include oligonucleotides and other negatively charged capture molecules, such as antibodies, antigens, peptides, receptors, haptens and ligands for receptors (which may be modified to introduce (additional) negative charges). Preferred are oligonucleotides. However, the scope of the invention is not limited to these specific molecules. The method may very well be useful to supports loaded with other types of molecules as well.

The invention is further illustrated by the following examples.

EXAMPLES

Preparation of APS-membranes:

Membranes (Anodisc 25, 0.2 um; Whatman) were silanated by placing them in a 1 % solution of 3-aminopropyltriethoxysilane (Acros, APS) in demineralised water (milliQ), for a period of 1 hr on a plateshaker. The membranes were soaked in water to remove the bulk of the APS molecules and subsequently washed individually by sucking 5 ml of milliQ through the membranes to remove the last traces of free APS. These membranes were heated for 2 hr's at 120 °C under vacuum. After cooling, these "APS-membranes" were stored in a vacuum exsiccator, under argon over KOH until they were used.

Stability study of APS-membranes:

The following buffers were made:

- 40 mM Acetate buffer pH 5.0; from sodiumacetate and acetic acid
- 40 mM Acetate buffer pH 6.0; from sodiumacetate and acetic acid
- 40 mM Phosphate buffer pH 7.0; from sodiumdihydrogenphosphate and NaOH
- 40 mM Borate buffer pH 8.0; from sodium tetraborate and hydrogen chloride
- 40 mM Borate buffer pH 9.0; from sodium tetraborate and hydrogen chloride

The APS membranes were incubated at the above mentioned pH's using the appropriate buffer for a period between 0.25 and 22 hr's (see table 1, for details). After this period the membrane was removed from the buffer solution and washed with milliQ and ethanol and dried under vacuum at room temperature. Subsequently the amount of amino-groups was determined using a modified trinitrobenzenesulfonic acid (TNBS) method [Habeeb, A.F.S.A. (1996), Anal. Biochem. **14**, 328. See also Sashidhar, R.B., Capoor, A.K., Ramana, D., (1994), J. Immumol. M]. A commercially available stock solution (Sigma) of 5% (m/v) of TNBS was diluted 25-fold with a 50 mM borate buffer of pH 10.0 directly before the amino-group determination was performed. Each treated membrane was placed individually in a beaker and 4 ml of the diluted

TNBS solution was added and the membrane was incubated on a plateshaker for 1 hr at room temperature. The yellow/orange membranes were thoroughly washed (by using vacuum to suck liquids through the membrane) with milliQ to remove excess TNBS. Subsequently the membranes were dissolved in a known amount (e.g. 4.0 ml) of a 4.0 M NaOH solution in milliQ. After filtration of this solution over a 0.45 µm filter, the absorption was measured using an UV/vis spectrophotometer. Using the extinction coefficient of the adduct at 390 nm of 11929 l/mol/cm, the number of amino groups per membrane that reacted with TNBS could be determined. In table 1 the decrease (in %) in amino-groups as function of time and pH is given.

Time (hr)	Percentage of aminogroups at				
	pH 5.0	pH 6.0	PH 7.0	pH 8.0	pH 9.0
Blanc exp.	100	100	100	100	100
0.25	54				
0.5	19				
1	9				
1.5		49			
2.5		17	82	96	51
6			69	52	34
22			54	42	21

Table 1: degradation as function of pH and time of APS membranes

From this table it is clear that the loss of aminogroups is fastest at lower pH's.

Protective effects of loading of the activated surface of a support:

(a) Protective effect of the TNBS group:

In another experiment the aminogroups on an APS membrane reacted with TNBS as described above. This yielded membranes that contain covalently linked chromophores that consist of the trinitrobenzene adduct of the amino group (APS-TNB membranes).

These membranes were treated with the same buffers mentioned above for a period of 22 hr's at room temperature. In table 2 the remaining amount of chromophores after this period, as determined with the above mentioned method, are summarized.

pH applied	Resulting aminogroups cq chromophores (%)
Blanc experiment	100
5.0	71
6.0	95
7.0	83
8.0	90
9.0	95

Table 2: stability of TNB-APS membranes

This table clearly shows, that functionalisation of the aminogroups results in a large increase of the stability. In other words, the majority of the functionalized aminogroups attached to the surface is not affected.

(b) Protective effect of DNA

A haring sperm DNA solution of 1 µg/ml in milliQ was prepared and 1 µl of this solution was pipetted onto the APS membranes in spots. These membranes were devided in two sets: one which was treated with pH 5 buffer (for 1 hr) and the other which were not. Both sets of membranes were subsequently treated with TNBS (method described above) in order to detect any decrease in amino-groups. This yielded the following results. The total surface of the untreated membrane showed the expected orange colour since no degradation (removal) of APS groups had taken place. The surface of the membrane that was treated at pH 5.0 was not orange but very slightly yellow, due to the degradation of nearly all APS molecules. However, at the spots where the DNA was pipetted on the membrane, an orange colour was still visible, indicating the protective effect of the DNA on the degradation process of the aminogroups on the surface. It was shown in a blanc experiment that the amino groups of DNA did not react

with TNBS in such a way that this could explain the orange colour observed for the pH 5 treated membrane.

(c) Protective effect of oligonucleotides

A solution of 200uM oligonucleotide with the sequence 5'TAT GGC TCT CCC GGG AGGGGG GGT CCT GGA 3' was prepared. This solution was pipetted onto two unmodified membranes and onto two APS membranes. In this process only one half of every membrane was covered with the oligonucleotide. Subsequently these membranes were dried at 37 °C for one hr. One unmodified and one APS membrane were treated with pH 5 solution as described above. Subsequently all membranes were washed with phosphate buffer pH 7.4 and ethanol and dried. All membranes were placed in the diluted TNBS solution as described above and incubated for one hr. After washing and drying, the unmodified membranes were totally white, while the total surface of the APS membrane that was not treated with pH 5 was yellow.
The pH 5 treated APS membrane showed a slightly yellow color on the half that was covered with the oligonucleotides while the other half was totally white.
This experiments clearly shows the protective effect of oligonucleotides.

(d) Arrays of oligonucleotides:

The protective effect was also visualised in a different way using hybridization of oligonucleotides:
Using a commercially available spotter (Packard instruments), droplets of 300 picoliter of oligonucleotide A (100 μM dissolved in milliQ) were spotted onto APS membranes:
This oligonucleotide A is defined by the sequence: 5'-TTG TAC AGA ACT GGA AAA GGA 3'. Also available for hybridization experiments is oligonucleotide B (sequence 5'-TCC TTT TCC AGT TCT GTA CAA 3') which is complementary to A and labeled with a fluoresceine moiety at the 5' end.

After spotting, all membranes were dried at 50 °C for 1 hr. One set of membranes was incubated in an acetate buffer (40 mM, pH 5.0) for 30 minutes and subsequently washed with

milliQ, ethanol, and dried under vacuum. These membranes will be referred to as "pH 5 arrays". As a blanc experiment the other set of membranes was not treated with the pH 5.0 solution, but it was only washed with milliQ, ethanol and dried under vacuum. These membranes will be called "blanc array". All membranes were stored under argon untill being used for hybridisation experiments.

The membranes were placed in a homebuilt device that allows 25 µl of a phosphate buffer (pH 7.0) containing the complementary oligonucleotide **B** being flushed back and forth through the membrane. If the solution is below this device, a hybridised nucleotide on the membrane can directly be seen due to its fluorescent label using an ordinary fluorescence microscope and a CCD-camera. With this setup, the data in table 3 have been collected. One cycle is defined as the 25 µl being pumped up and down one time through the membrane. Specific signals have been corrected for the background signal.

	Signal (arb.units) for pH 5 arrays			Signal (arb.units) for blanc arrays	
Cycles	Specific	Background	Cycles	Specific	Background
0	0	5	0	0	5
2	4	8	1	0	41
5	7	8	5	2	47
10	11	9			
15	13	9			
20	15	9			

Table 3: Specific and a-specific interactions of pH 5 arrays and blanc arrays

From this table the following observations are important:

- The background signal for pH 5 arrays is low and nearly constant
- The specific hybridisation for pH 5 arrays takes place rapidly and can easily be monitored

- The blanc array does not show specific signals, due to a strong a-specific interaction between the amino-groups (which are present all over the membrane) and oligonucleotide B.
- The a-specific interactions (background) that are seen for the blanc arrays, is highly reduced by the acidic treatment.

Thus, this experiment shows that the acidic treatment removes all amino groups that are not covered and protected by oligonucleotides. Oligonucleotide A is not removed from the surface indicating that it is still captured by aminogroups on the surface below the nucleotides which have not been removed.

CLAIMS

1. A method for the preparation of metal oxide supports loaded with biomolecules, comprising the steps of :

(a) activating the surface of the support by means of a silanating agent comprising an amine group;

(b) loading the support by attaching biomolecules to the activated surface,

characterized in that subsequently the loaded support is treated with an acidic solution, and provided that the method is not used for the preparation of silica wafers which are aminated by silanation using (3-aminopropyl)monoethoxydimethylsilane and loaded with oligonucleotides.

2. A method for the preparation of metal oxide supports loaded with biomolecules, comprising the steps of :

(a) activating the surface of the support by means of a silanating agent comprising an amine group;

(b) loading the support by attaching biomolecules to the activated surface,

characterized in that subsequently the loaded support is treated with a basic or neutral solution, and provided that the method is not used for derivatization of aluminiumoxide nanoparticles aminated with (3-aminopropyl)triethoxysilane, wherein the basic solution further contains a large excess of N-acetylhomocysteinelactone.

3. The method of claim 1, wherein the solution is of pH 2 to 7 .

4. The method of claim 3, wherein the biomolecules are oligonucleotides and the pH is 4-5.

5. The method of claim 1, wherein the metal oxide support is a (electrochemically manufactured) porous metal oxide membrane.

6. The method of claim 5, wherein the metal oxide is aluminium oxide.

7. The method of claim 1, wherein the support is activated by means of a silanating agent comprising an amine group selected from 3-aminopropyltriethoxysilane, 4-aminobutyl-dimethyl-methoxysilane, 3-[2-(2-aminoethylamino)ethylamino]propyl-trimethoxysilane, 3-(2-aminoethylamino)propyl-methyldimethyoxysilane, 3-(2-aminoethylamino)propyl-trimethyoxysilane, 3-aminopropyl-methyl-diethoxysilane, (3-aminopropyl)tris[2-(2-methoxyethoxy)ethoxy]silane and 4-aminobutyltriethoxysilane,

8. The method of claim 7, wherein the silanating agent comprising an amine group is 3-aminopropyltriethoxysilane.

9. The method of claim 8, wherein 3-aminopropyl triethoxysilane is used in an unbuffered aqueous solution.

10. The method of claim 1, wherein the biomolecules are adsorptively attached to the activated surface of the support.

11. The method of claim 1, wherein the biomolecules are attached to the activated surface in spots, thereby forming an array of spots.

12. The method of claim 11, wherein the biomolecules attached to the surface in different spots may be the same or different.

13. The method of claim 1, wherein the biomolecules are oligonucleotides.

14. A loaded metal oxide support prepared according to the method of claim 1.

15. An aminoalkyltrialkoxysilane-activated metal oxide support, provided with an array of spots of biomolecules attached to the support, characterized in that on the array the density of amino groups on the surface area between the spots is significantly lower than the density of amino groups in the spots.

16. Use of the metal oxide support of claim 14 or 15 for performing a probe-based assay.

17. A kit of parts comprising the metal oxide support of claim 14 or 15, further comprising a detection means for determining whether binding has occurred between the biomolecules and an analyte.

18. A kit according to claim 17, wherein the detection means is a substance capable of binding to the analyte and being provided with a label.

19. A kit according to claim 18, wherein the label is capable of inducing a colour reaction and/or capable of bio-, chemo- or photoluminescence.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
99485 WO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 00/ 07736	09/08/2000	16/08/1999
Applicant		
PAMGENE B.V.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. --

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 00/07736

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C12Q1/68 G01N33/553

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C12Q G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, MEDLINE, BIOSIS, EMBASE, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 99 02266 A (AKZO NOBEL NV ;DAMME HENDRIK SIBOLT VAN (NL); KREUWEL HERMANUS JOH) 21 January 1999 (1999-01-21) cited in the application * see especially claims 1-4 as well as examples 2-4 * the whole document	1-19
Y	EP 0 391 608 A (MINNESOTA MINING & MFG) 10 October 1990 (1990-10-10) the whole document	1-14

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 January 2001	22/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Knehr, M

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	BALLADUR V ET AL.: "Determination of the main forces driving DNA oligonucletide adsorption onto aminated silica wafers" JOURNAL OF COLLOID AND INTERFACE SCIENCE, vol. 194, 1997, pages 408-418, XP000870394 cited in the application abstract; figures 1,2 page 408, column 1, paragraph 1 -page 411, column 1, paragraph 2; figure 1 ---	15-19
A	FREY A ET AL.: "Peptomer aluminium oxide nanoparticle conjugates as systemic and mucosal vaccine candidates: Synthesis and characterization of a conjugate derived from the C4 domain of HIV-1MN Gp120" BIOCONJUGATE CHEMISTRY, vol. 8, 1997, pages 424-433, XP002128670 cited in the application abstract page 425, column 2, paragraph 3 -page 426, column 1, paragraph 2; figures 1,2 ---	
A	WOJCIK S M AND PULEO D A: "Biochemical surface modification of Ti-6Al-4V for the delivery of protein to the cell-biomaterial interface" BIOMEDICAL SCIENCES INSTRUMENTATION, vol. 33, 1997, pages 166-171, XP000870316 abstract; figures 1,2 page 166, paragraph 1 -page 168, paragraph 1; figures 1,2 ---	
A	FADDA M B ET AL: "COVALENT COUPLING OF CONCANAVALIN A TO COMMERCIAL ALUMINA" BIOTECHNOLOGY AND APPLIED BIOCHEMISTRY,US,ACADEMIC PRESS, vol. 16, page 221-227 XP002050223 cited in the application the whole document paragraph 2; figure 1 ---	
A	WO 92 22201 A (BAXTER DIAGNOSTICS INC) 23 December 1992 (1992-12-23) the whole document -----	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 00/07736

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9902266 A	21-01-1999	AU 724382 B	21-09-2000
		AU 8863298 A	08-02-1999
		EP 1050588 A	08-11-2000
		EP 0975427 A	02-02-2000
EP 0391608 A	10-10-1990	AU 5126890 A	04-10-1990
		CA 2011929 A	03-10-1990
		JP 2286100 A	26-11-1990
WO 9222201 A	23-12-1992	AU 654381 B	03-11-1994
		AU 2238492 A	12-01-1993
		CA 2087976 A	18-12-1992
		DE 69203080 D	27-07-1995
		DE 69203080 T	01-02-1996
		EP 0543988 A	02-06-1993
		ES 2076773 T	01-11-1995
		JP 2844263 B	06-01-1999
		JP 6500358 T	13-01-1994

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

6

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PAM-003-PCT		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP00/07736	09/08/2000	16/08/1999
International Patent Classification (IPC) or national classification and IPC C12Q1/68		
Applicant PAMGENE B.V.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09/03/2001	29.11.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Luzzatto, E Telephone No. +49 89 2399 8169

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/07736

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-12	as originally filed				

Claims, No.:

4-19	as originally filed				
1-3	as received on	16/11/2001	with letter of	12/11/2001	

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:
   - ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-13
	No:	Claims	14-19
Inventive step (IS)	Yes:	Claims	1-13
	No:	Claims	14-19
Industrial applicability (IA)	Yes:	Claims	1-19
	No:	Claims	

2. Citations and explanations
   see separate sheet

PART V

1) None of the available documents disclose or suggest a method for removing non-loaded amino groups which are part of a silanating agent used to prepare a metal oxide solid support having immobilised thereon biomolecules as that to which independent claims 1 and 2 relate.
D1 (Fadda et al., Biotechnol. Appl. Biochem., 16, 221-27, 1992) teaches a method for the immobilisation of biomolecules on a metal oxide support comprising the same steps as that of claim 2 but falls short of disclosing that the methods leads to the removal of non-loaded amino groups; it refers to such a treatment as a thorough wash (see p. 222 "Experimental").
The same applies also to the following documents:
-WO9902266 (D2), which discloses the preparation of a metal oxide support loaded with nucleic acids by means of a silanating agent (example 2),
- Balladur et al. (D3) (J. Coll. Interface Sci., 194, 408-18, 1997), which merely disclose the use of a washing buffer "...to remove adsorption solution." (p. 409-410) and
- Frey et al. (D4) (Bioconjug. Chem., 8, 424-32, 197) which disclose the use of PBS to wash the biomolecule-loaded metal oxide (p. 426).
Hence, claims 1 and 2 meet the requirements of Art. 33 EPC.
The same applies to dependent claims 3-13.

2) On the other hand, the solid support obtained by the any of the methods of D1-D4 appears to be identical with that obtainable by the method of claim 1. Claims 14 and 15, therefore, lack novelty (Art. 33(2) PCT). As to D2, a washing step is implicitly disclosed in example 2, because without such a step it would be impossible to quantify the results of the coupling procedure with radioactive probes.

3) Claims 16-19 lack novelty over D2 which discloses the use of the device in probe-based assays and kits comprising it (see claims).

① for removing non-loaded amino groups which form part of the silanating agent used to activate the metal oxide surface during

CLAIMS

1. A method ~~for~~ the preparation of metal oxide supports loaded with biomolecules, comprising the steps of:

(a) activating the surface of the support by means of a silanating agent comprising an amine group;

(b) loading the support by attaching biomolecules to the activated surface, and,

(c) treating said ~~characterized in that subsequently the~~ loaded support ~~is treated~~ with an acidic solution, ~~and provided that the method is not used for the preparation of silica wafers which are aminated by silanation using (3-aminopropyl)monoethoxydimethylsilane and loaded with oligonucleotides.~~

2. A method ~~for~~ the preparation of metal oxide supports loaded with biomolecules, comprising the steps of:

(a) activating the surface of the support by means of a silanating agent comprising an amine group;

(b) loading the support by attaching biomolecules to the activated surface, and,

(c) treating said ~~characterized in that subsequently the~~ loaded support ~~is treated~~ with a basic or neutral solution, ~~and provided that the method is not used for derivatization of aluminiumoxide nanoparticles aminated with (3-aminopropyl)triethoxysilane, wherein the basic solution further contains a large excess of N-acetylhomocysteinelactone.~~

3. The method of claim 1 or 2, wherein the solution is of pH 2 to 7.

~~4. The method of claim 3, wherein the biomolecules are oligonucleotides and the pH is 4-5.~~

5. The method of claim 1, wherein the metal oxide support is a (electrochemically manufactured) porous metal oxide membrane.

~~6. The method of claim 5, wherein the metal oxide is aluminium oxide.~~

PATENT COOPERATION TREA

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

DE CLERCQ, A.
DE CLERCQ, BRANTS & PARTNERS
E. Gevaertdreef 10a
B-9830 Sint-Martens-Latem
BELGIQUE

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	29.11.2001
Applicant's or agent's file reference: PAM-003-PCT	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP00/07736	09/08/2000	16/08/1999

Applicant: PAMGENE B.V.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Digiusto, M Tel.+49 89 2399-8162

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

DE CLERCQ, Ann
De Clercq, Brants & Partners
E. Gevaertdreef 10 a
B-9830 Sint-Martens-Latem
BELGIQUE

Date of mailing (day/month/year) 19 April 2001 (19.04.01)	
Applicant's or agent's file reference PAM-003-PCT	**IMPORTANT NOTIFICATION**
International application No. PCT/EP00/07736	**International filing date** (day/month/year) 09 August 2000 (09.08.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
PAMGENE B.V. Grote Gent 2 NL-5261 BT Vught Netherlands	NL	NL
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
PAMGENE B.V. Burgemeester Loeffplein 70 a NL-5211 RX Den Bosch Netherlands		
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[X] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer J. Leitao
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

Form PCT/IB/306 (March 1994)

003974861

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

DE CLERCQ, Ann
De Clercq, Brants & Partners
E. Gevaertdreef 10 a
B-9830 Sint-Martens-Latem
BELGIQUE

Date of mailing (day/month/year)
19 April 2001 (19.04.01)

Applicant's or agent's file reference
PAM-003-PCT

IMPORTANT NOTIFICATION

International application No.
PCT/EP00/07736

International filing date (day/month/year)
09 August 2000 (09.08.00)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address
PAMGENE B.V.
Grote Gent 2
NL-5261 BT Vught
Netherlands

State of Nationality: NL
State of Residence: NL
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address
PAMGENE B.V.
Burgemeester Loeffplein 70 a
NL-5211 RX Den Bosch
Netherlands

State of Nationality:
State of Residence:
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[X] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
J. Leitao
Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

42

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING DOCUMENT TRANSMITTED

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as designated Office

Date of mailing (day/month/year)	
19 April 2001 (19.04.01)	
International application No.	**International filing date** (day/month/year)
PCT/EP00/07736	09 August 2000 (09.08.00)
Applicant	
PAMGENE B.V. et al	

The International Bureau transmits herewith the following documents and number thereof:

_____ cop(ies) of priority document(s) (Rule 17.2(a))

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

J. Leitao

Telephone No.: (41-22) 338.83.38

P ENT COOPERATION TREA

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

DE CLERCQ, Ann
De Clercq, Brants & Partners
E. Gevaertdreef 10 a
B-9830 Sint-Martens-Latem
BELGIQUE

Date of mailing (day/month/year)
19 April 2001 (19.04.01)

Applicant's or agent's file reference
PAM-003-PCT

IMPORTANT NOTIFICATION

International application No.
PCT/EP00/07736

International filing date (day/month/year)
09 August 2000 (09.08.00)

1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [X] the agent [ ] the common representative

Name and Address
HOGENBIRK, M.
P.O. Box 20
NL-5340 BH Oss
Netherlands

State of Nationality:
State of Residence:
Telephone No.: 0412-666360
Facsimile No.: 0412-650592
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [X] the address [ ] the nationality [ ] the residence

Name and Address
DE CLERCQ, Ann
De Clercq, Brants & Partners
E. Gevaertdreef 10 a
B-9830 Sint-Martens-Latem
Belgium

State of Nationality:
State of Residence:
Telephone No.: +32 (09) 280 23 40
Facsimile No.: +32 (09) 280 23 45
Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[X] the designated Offices concerned
[ ] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
J. Leitao
Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 25 May 2001 (25.05.01)	
International application No. PCT/EP00/07736	**Applicant's or agent's file reference** PAM-003-PCT
International filing date (day/month/year) 09 August 2000 (09.08.00)	**Priority date** (day/month/year) 16 August 1999 (16.08.99)
Applicant VENEMA F.	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

09 March 2001 (09.03.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Claudio Borton
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38